

OCCASIONAL PAPERS OF THE
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CALATHASPIS
A NEW GENUS OF THE LICHEN FAMILY CLADONIACEAE

I. MACKENZIE LAMB,¹ WILLIAM A. WEBER,²
H. MARTIN JAHNS,³ & SIEGFRIED HUNECK⁴

Calathaspis M. Lamb & W. Weber (n. gen.).

Genus Cladoniacearum ex affinitate *Gymnodermais* Nyl., quocum habitu et modo formationis apotheciorum (podetiis brevissimis suffultorum) simile est, praesertim sporis transversim multiseptatis differens. Thallus microphyllino-laciniatus, saltem superne corticatus, erhizinosus, medulla hyphose contexta. Algae ad Chlorococcaceas pertinentes. Apothecia in facie inferiore squamularum oriunda, scutelliformia, algas nullas fovientia. Paraphyses tenuiter filiformes. Sporae incolores, septis tenuibus. Typus et species unica adhuc cognita:

Calathaspis devexa M. Lamb & W. Weber (n. sp.).

Diagn. Thallus microphyllinus aut laciniatus, laciniis sparsis vel laxissime imbricatis, prostratis vel partim erectis, basi substrato affixis, subdichotome vel flabellatim divisis, planis vel leviter convexis, superne viridoglauciscentibus, inferne albidis, evenatis, glabris, rhizinis nullis. Cephalodia, isidia et soredia desunt. Algae symbioticae trebouxioideae, laete virides. Thallus superne manifeste corticatus, inferne tenuius et indistinctius corticatus, cortice incolori, gelatinoso, cellulis valde pachydermatis et confluentibus. Medulla incolor, fere transparens, hyphis discretis, laxae vel partim sat dense intricatis.

Apothecia in facie ventrali squamularum enata, facie lecideina, rotundata, scutelliformia, 0.8-1.2 mm lata, disco nigrescenti et nudo, plano vel concaviusculo, margine proprio tenui, persistente, integro, disco nonnihil pallidiori; subtus distincte pedicellata; excipulum proprium incolor, algas nullas fovens, manifeste pseudoparenchymaticum, cellulis valde pachydermatis. Hypothecium parte superiori flavidofuscum, inferne pallidius coloratum. Hymenium 110-150 μ altum, epithecio flavido-

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fusco, paraphysibus tenuibus, filiformibus. Asci clavati, normaliter 8-sporei. Sporae biseriatae, hyalinae, naviculoideo-fusiformae, utrinque obtuse attenuatae, transversim multiseptatae (septis 7-9, tenuibus), longit. 45-50 μ , crassit. 11-13 μ .

React. et mat. chim.: thallus K—, C—, PD+ (in facie ventrali albicanti) roseo-rubescens; medulla I—; hymenium I+ persistenter caerulescens. Thallus substantiam adhuc ignotam continet.

Typus: Nova Guinea, Pindaunde, Mt. Wilhelm, altit. ca. 3500 m, ad ramunculos arborum in sylva subalpina, coll. D. McVean, 1967 (no. 6782); holotypus in Herbario Farlowiano Universitatis Harvardianae, isotypi in Museo Universitatis Coloradoensis et in herbariis Canberra (Australia) et Lae (Nova Guinea).

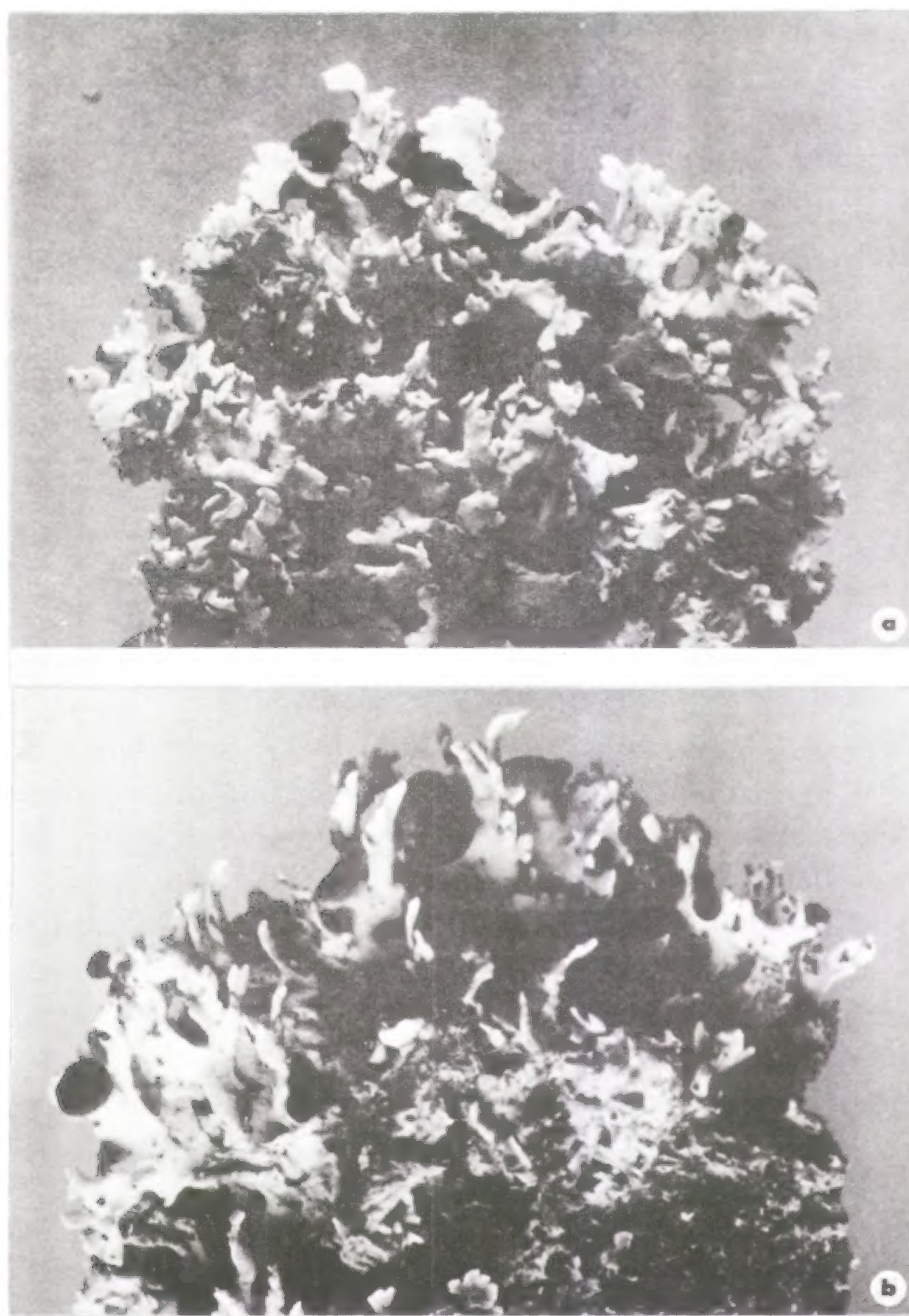


FIG. 1

Descript. Thallus minutely caespitose, of small crowded laciniolate squamules attached by the base and without rhizinae. Lacinae imbricate, prostrate or partly erect, subdichotomously or flabellately divided, plane or slightly convex, 2-5 mm long, 0.3-0.6 (–0.8) mm wide, 0.2-0.3 mm thick; upper side glaucous-greenish, smooth, matt, non-pruinose; lower side whitish, smooth, without veins, glabrous, matt. No cephalodia, isidia or soredia. Symbiotic algae chlorococcalean, trebouxoid, bright green, globose, separate, 8-12 μ diam. Dorsal side of thallus with a colorless, hyaline, gelatinized cortex 20-75 μ thick consisting of confluent, intertexted, very thick-walled hyphae 9-12 μ wide with rounded or elongated lumina 1-2 μ wide. Algal stratum continuous below cortex, regular, 30-80 μ deep. Medulla colorless or faint isabelline, almost transparent but slightly isabelline-granulose in uppermost part, consisting of discrete, laxly or partly somewhat densely intricate, moderately thick-walled hyphae 3-5 μ wide running in various directions. Ventral side of thallus more thinly and less distinctly corticate than dorsal side; its rudimentary cortex ca. 10 μ thick, transitional into the medullary tissue, colorless, hyaline, composed of gelatinized and very thick-walled hyphae 6-8 μ wide.

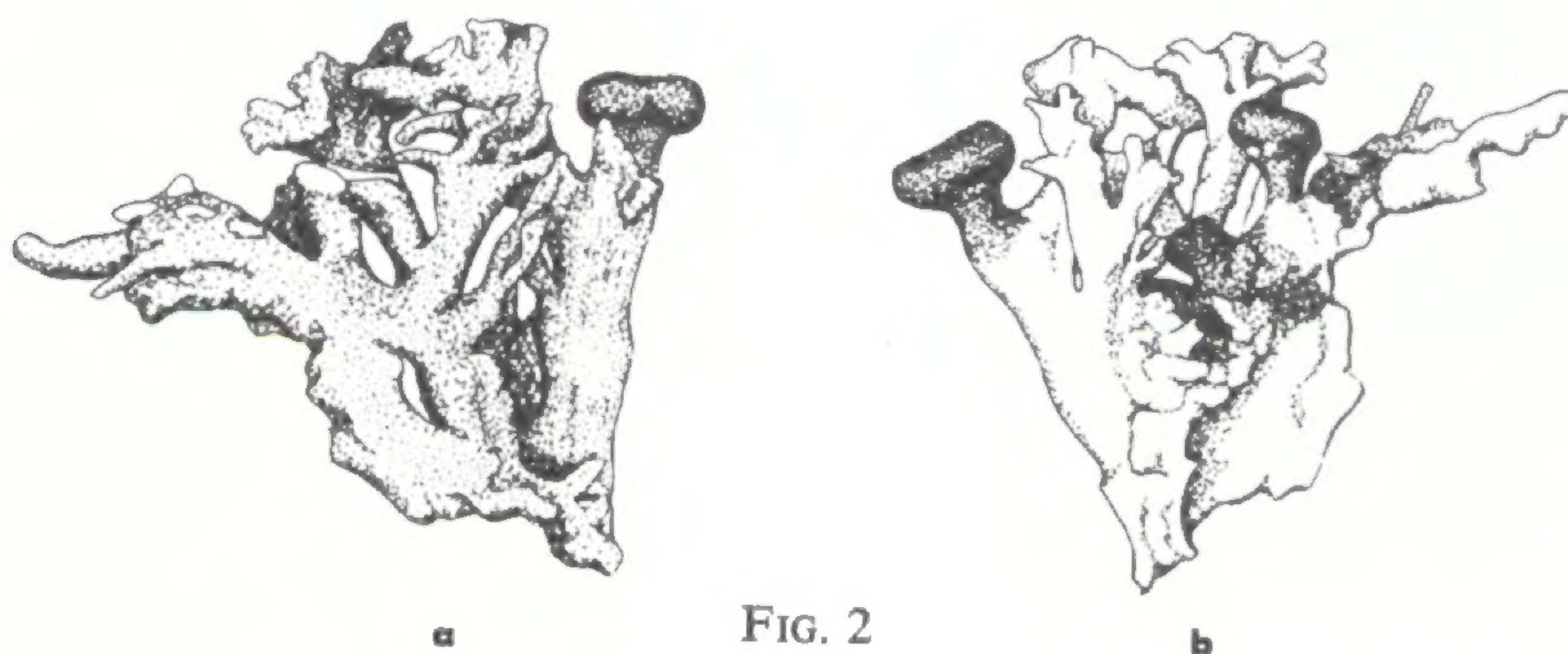
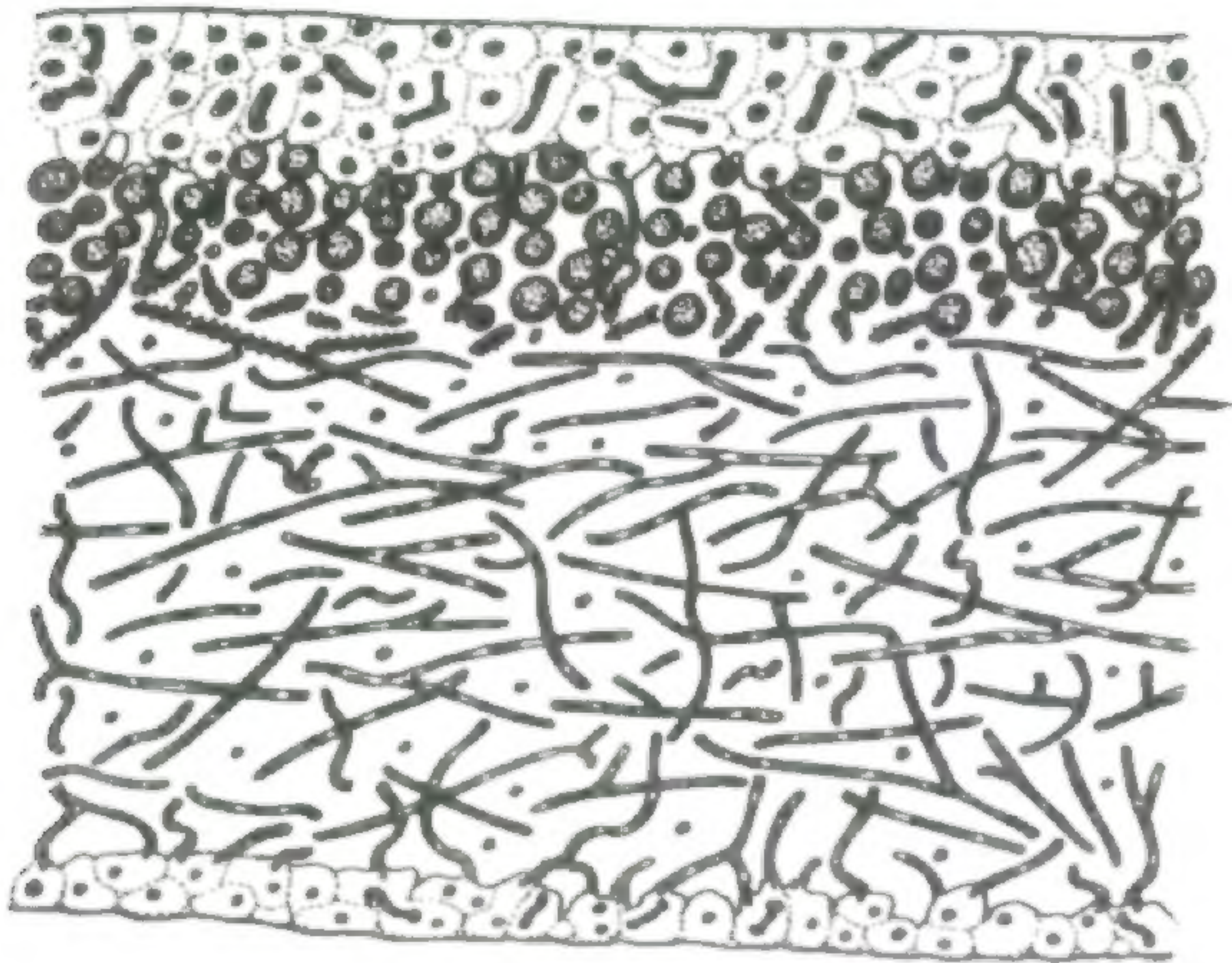
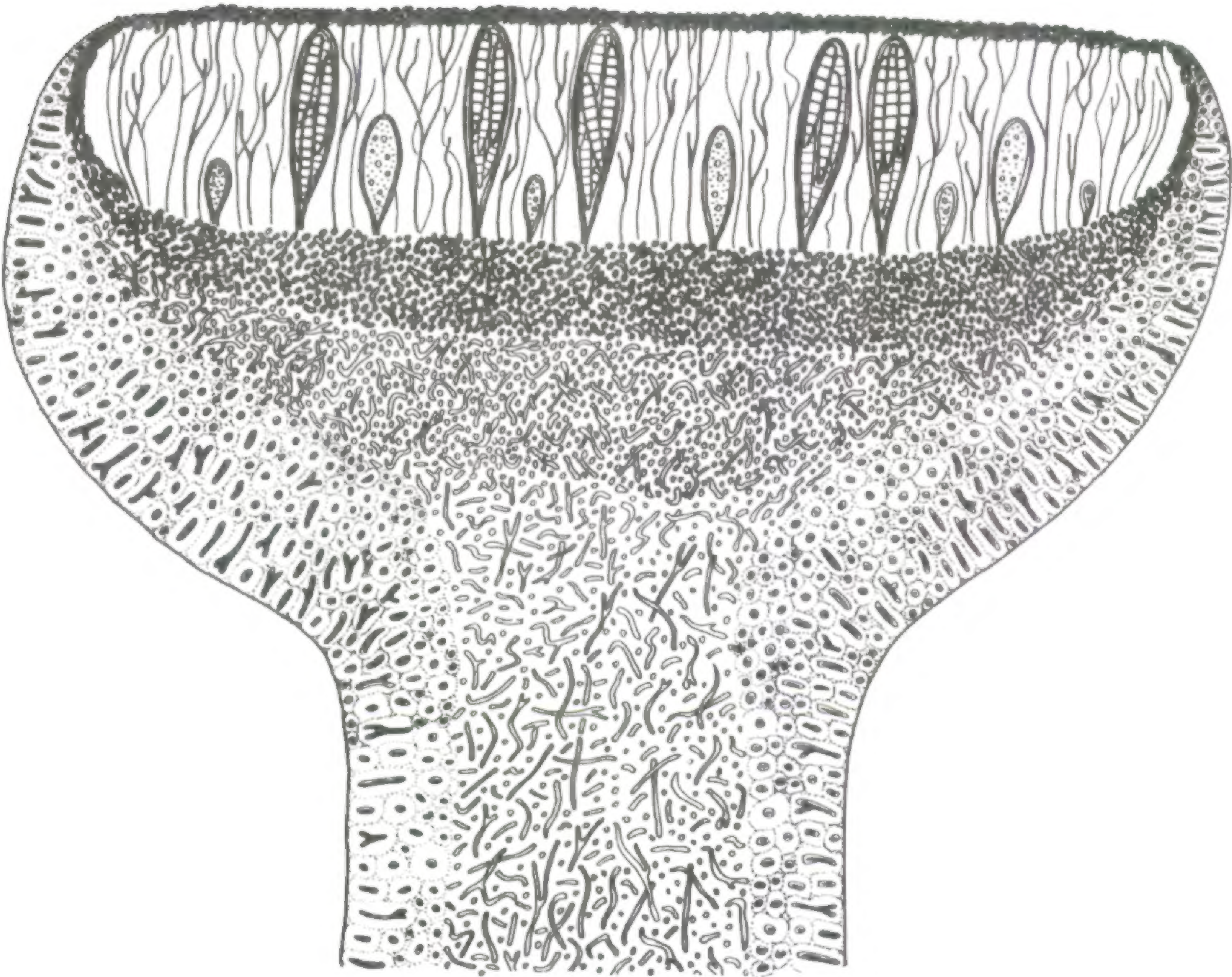


FIG. 2

Apothecia borne on ventral side of thalline lacinae, of lecideine appearance, round, scutelliform, 0.8-1.2 mm diam., distinctly pedicellate; disc blackish, matt, non-pruinose, plane or slightly concave; proper margin thin, persistent, entire, somewhat paler than the disc (olivaceous-brownish or finally brown-blackish), subtended on lower side of apothecium by a smooth, dark gray-brownish receptacle. Apothecia internally without algae. Proper margin colorless and hyaline in section, distinctly pseudoparenchymatous with very thick-walled, gelatinously confluent, isodiametric or radially elongated cells with walls 3.0-4.5 μ thick, their lumina 3-6 μ wide. Hypothecium yellow-brownish in upper part due to amorphous pigment deposited between the hyphae, paler below, composed of compactly interwoven hyphae about 5 μ thick. Hymenium 110-150 μ high, with yellowish-brown, granulose epithecium; para-



a



b

150 μ

FIG. 3

physes slender, filiform, embedded in gelatinous matrix, sinuose, ca. $0.7\ \mu$ thick, slightly knobbed at tips (to 1.5 or $2.0\ \mu$), branched and sometimes interconnected. Asci clavate, with gelatinous wall ca. $3\ \mu$ thick, 120 - $135\ \mu$ long, 20 - $28\ \mu$ broad. Spores normally 8 in ascus (sometimes 4-6), irregularly biserially arranged, colorless, highly refractive, naviculoid-fusiform, bluntly attenuate at both ends, with 7-9 thin transverse septa, 45 - $50\ \mu$ long, 11 - $13\ \mu$ broad.

(Pycnidia not seen.)

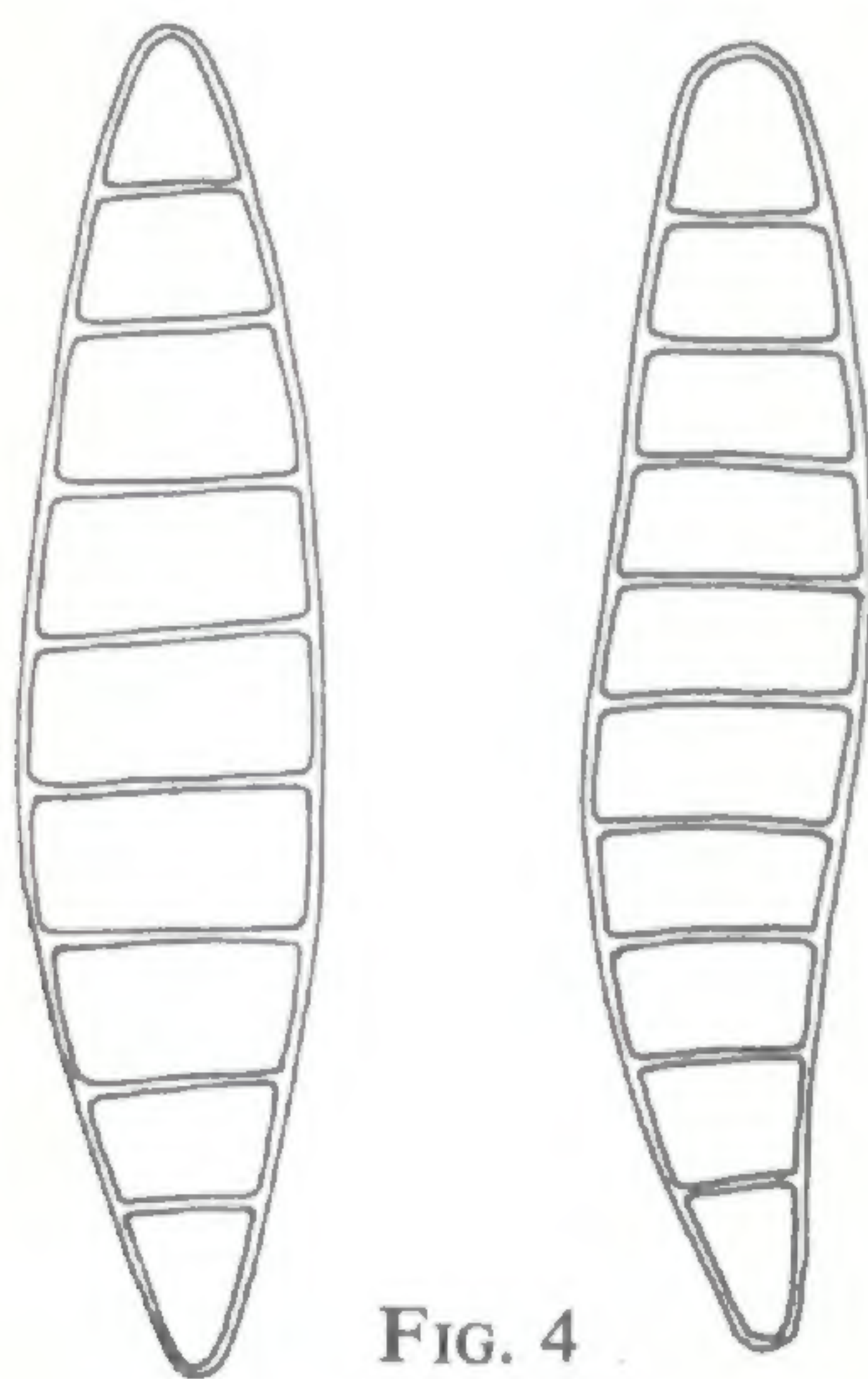


FIG. 4

Thallus K—, C—, PD + rose-reddish on pale underside; medulla I—; ascus-walls and hymenial mucilage I + persistent blue.⁵ Thallus containing an unknown lichen substance showing some similarity to panarin.

Name derived from Gr. *κάλαθος*, a vase-shaped vessel, and *ἀσπίς*, a shield (from the shape of the apothecia), and Lat. *devexus*, sloping, directed downwards (from the arrangement of the thalline laciniae).

Four collections of this species have been made to date:

NEW GUINEA, Eastern Highlands: Mt. Wilhelm, Pindaunde Field Station, vicinity of Lake Aunde, altit. ca. 3500 m, on fine twigs at margin of subalpine forest, coll. D. McVean, July 1967 (no. 6782, type material, FH, COLO, CANB, LAE); same locality, coll. W. A. Weber & D. McVean, July 1968 (nos. L-48411, L-48413, COLO); Daulo Pass, altit. 2500 m, on saplings in regenerating forest on south ridge along

⁵ K stands for a mixture of equal parts of 5 per cent potassium hydroxide (KOH) and 20 per cent potassium carbonate (K_2CO_3), both in aqueous solution; C, a fresh saturated aqueous solution of calcium hypochlorite ($Ca(ClO)_2$); PD, paraphenylenediamine ($C_6H_4(NH_2)_2$), 5 per cent solution in 95 per cent alcohol, freshly made up for each occasion; I, iodine dissolved in an aqueous solution of potassium iodide and diluted to a light brown color.

native garden track, coll. W. A. Weber & D. McVean, June 1968 (no. L-50221, FH, COLO, CANB, LAE).⁶

Calathaspis devexa has been collected at two widely separated localities in the Eastern Highlands and at significantly different altitudes and forest types. The type collection came from scattered tree "islands" of the subalpine cloud forest on the slopes of Imbuka and Bogonotto ridges just above the tussock grasslands dominated by *Deschampsia klossii* and *Danthonia penicillata*. The other collection was from a heavily lumbered or cleared, now rapidly regenerating second-growth "mossy forest" originally dominated by *Nothofagus* and *Pandanus* and supporting a rich bryophyte understory if one may judge from the virgin forest of the ridge summit north of the highway. It is very likely, then, that the species is widely distributed in the middle and high-altitude forests of New Guinea at altitudes between 2000 and 4000 meters.

It seems to be confined to saplings of 2-10 centimeters diameter-breast-height. It does not grow on healthy barren bark but usually occurs on water-soaked, often moribund branches, mixed with creeping hepatics such as *Frullania*, *Radula*, *Metzgeria* or loosely-tufted mosses. On Mount Wilhelm the occurrence of the rare *Streptopogon erythrodontus* tended to indicate the nearby occurrence of *Calathaspis*. Thick bryophyte cover on the one hand (competition for light) and bare, healthy bark (aridity) on the other seem to be limiting to *Calathaspis*.

The thallus always grows down from its point of attachment toward the base of the tree. When moist the upper cortex is green, more or less plane, and the apothecia tend to be hidden or relatively inconspicuous (black on green). When dry, the thallus laciniae curve upward and outward, exposing the white ventral surface and framing the black apothecia on the white background. Since the plant is probably wet more of the time it tends to be inconspicuous and overlooked. At the same time, the condition for its success must be complicated enough to ensure its rarity or infrequency. It is distinctly a species of successional forest or of small, isolated groves of uneven age and broken shade. In a very few instances *Calathaspis* was found on the same sapling with *Compsocladium archboldianum* M. Lamb, but the latter grows best on small twigs and on bare bark, apparently having a low tolerance for associated vegetation.

⁶ CANB: Commonwealth Scientific & Industrial Research Organization, Division of Plant Industry, Canberra, Australia.

COLO: University of Colorado Herbarium, Museum, Boulder, Colorado, U.S.A.

FH: Farlow Herbarium of Cryptogamic Botany, Harvard University, Cambridge, Massachusetts, U.S.A.

LAE: Department of Forests, Lae, Papua and New Guinea.

The precise groves from which *Calathaspis* was taken were figured by Wade & McVean (1969, Plate 12). *Rhododendron atropurpureum* and species of *Olearia* were recognized as substrates, but many other species probably serve.

The taxonomic affinity of this new genus was not immediately clear. It was to be considered that it might belong to the family Phyllopsoraceae, of which one genus (*Psorella* Müll. Arg.) has transversely multiseptate spores; but the members of this family, which is most likely taxonomically heterogeneous as at present delimited, differ significantly from *Calathaspis* in having the thalline squamules rhizinose on the underside, the apothecia dorsally developed on the thallus and not stipitate, and the paraphyses simple and unbranched. The study of its ontogenetic development which follows does, however, reveal features entirely congruent with that of the family Cladoniaceae, in which it shows a distinct relationship with the genus *Gymnoderma* Nyl., and this relationship is attested also by its general morphological resemblance to the latter.

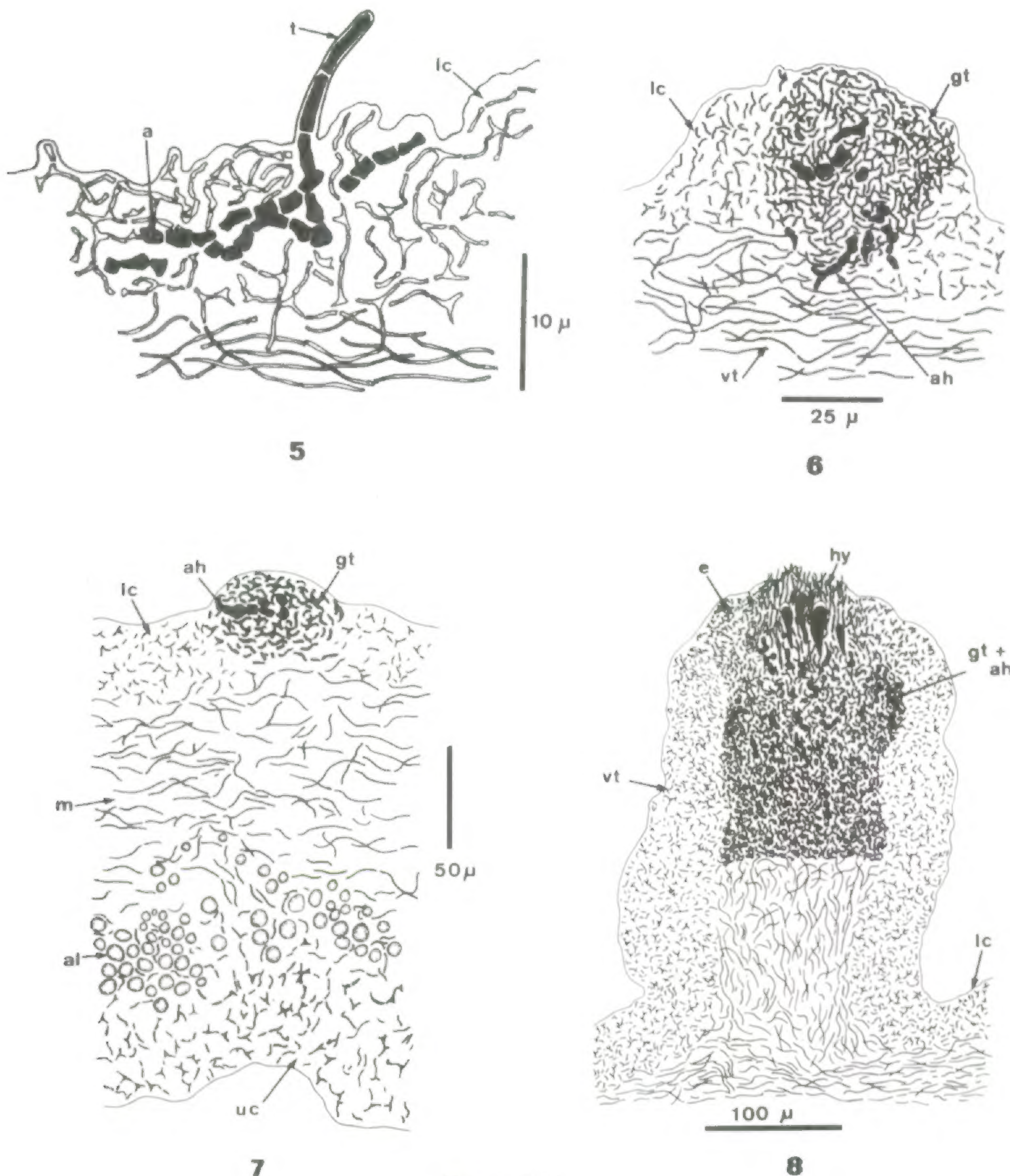
Three species of *Gymnoderma* are known, disjunctively distributed in eastern Asia and the southern Appalachians of N. America; a monographic revision has been published by Yoshimura and Sharp (1968). In at least two of the species of *Gymnoderma* the very short apothecial stalks ("thallus verticalis") originate on the ventral side of the thallus, and only later come to occupy the margin (Jahns, 1970). In *Calathaspis* the ventral position of the podetial structures and apothecia is much more pronounced. Sporologically, *Calathaspis* shows an advance over the simple non-septate spore type of *Gymnoderma* in its characteristic transversely multiseptate spores. Finally, its chemical constitution (see below) is distinct from any of the substances produced by the *Gymnoderma* species (the depside atranorin in *G. insulare* and *G. lineare*, the dibenzofuran didymic acid in *G. insulare*, the aliphatic compound protolichesterinic acid in *G. lineare*, and an unidentified substance in *G. coccocarpum*, according to Yoshimura & Sharp, *op. cit.*).

For a detailed study of the ontogeny of the ascocarps of *Calathaspis*, material of the type collection (McVean no. 6782) was cut with a freezing microtome and the sections stained with lactophenol-cotton blue.

In most lichen genera investigated the first stage of the ascocarp to be formed is the generative tissue, but in the present case a part of the sexual apparatus, the ascogone, appears first. It could be distinctly observed and is formed in the lower cortex, which is an unusual position for this structure. It consists of a straight row of cells with large lumina, contrasting with the smaller and irregularly branched cells of the cortex. Figure 5 shows an ascogone with an attached trichogyne, which has grown to the thallus-surface and emerges from it.

Only when the ascogenous hyphae have replaced the ascogone is the

generative tissue formed around them. The generative tissue is distinguished from the cortical tissue by its denser structure and the more intense staining of its cells. At this stage, as shown in Fig. 6, the young primordium still lies practically hidden in the thallus, but can already be seen externally as a dark reddish brown spot. This reddish brown color of the young fruiting body is due to a pigment which is deposited between the hyphae of the generative tissue, but which has been omitted in the drawing.



FIGS. 5-8

The generative tissue grows and the primordium, still unchanged in form, slowly rises above the surface of the thallus. This stage is shown in Fig. 7, which also gives a complete view of the thallus in section. The three stages just described would lead one to expect that by further growth of the generative tissue a true podetium (according to the definition of Jahns, 1970) would be formed; such a development is common

in the family of the Cladoniaceae. However, in *Calathaspis* the situation is more complicated, as can be seen from Fig. 8. The generative tissue has elongated and thereby caused the primordium to become much higher; however, the vegetative tissue also has contributed to this growth. The complex of generative tissue is enveloped by a sheath of vegetative tissue which not only has the same structure as the lower cortex of the thallus but has actually originated from it. This surrounding tissue is not unconnected with the generative tissue, for some hyphae pass from one tissue into the other. Nevertheless it is entirely clear that this cortex of the primordium is derived from the cortex of the thallus.

The medullary tissue of the thallus has likewise grown upwards, elevating the generative tissue, which thus comes to stand on a small pedestal. The ascogenous hyphae have divided and by growing upwards with the primordium have become distributed all through the generative tissue. At the upper end of the primordium a young hymenium with some immature asci has developed. The hymenium is surrounded by a small excipulum of generative tissue.

It is significant that at this point of the development the borderline between generative and vegetative tissue in the lower part of the primordium can be distinctly observed. This characteristic of the young ascocarp is preserved in the further development and makes it possible to observe another interesting fact, namely that the vegetative tissue, having unexpectedly formed a large part of the primordium, now, equally unexpectedly, plays no further role in its ontogeny.

The mature ascocarp, as shown in Fig. 9, consists for the most part of generative tissue, which is sessile on a comparatively small pedestal of vegetative tissue. The excipulum has enlarged considerably and is continuous with the cortex of the upper part of the podetium. The vegetative cortex tissue of the stage shown in Fig. 8 did not continue its growth.

The observation and interpretation of the various developmental stages is rendered easier by the deposition of pigment in the ascocarp. The granules of reddish brown pigment are not evenly distributed, but form a reticulating pattern, as seen in Fig. 9. Important is the fact that the granules are deposited in the generative tissue and completely disappear at the borderline to the vegetative tissue. In this way the borderline is distinctly indicated and the ontogeny of the ascocarp can therefore be understood more clearly.

On the basis of the foregoing observations, the question now arises whether the fruiting body of *Calathaspis* should be regarded as a podetium or a pseudopodetium, and to what other genera *Calathaspis* is related in regard to its ontogenetic development. If one applies to the "thallus verticalis" of this genus the strict definition that "a podetium

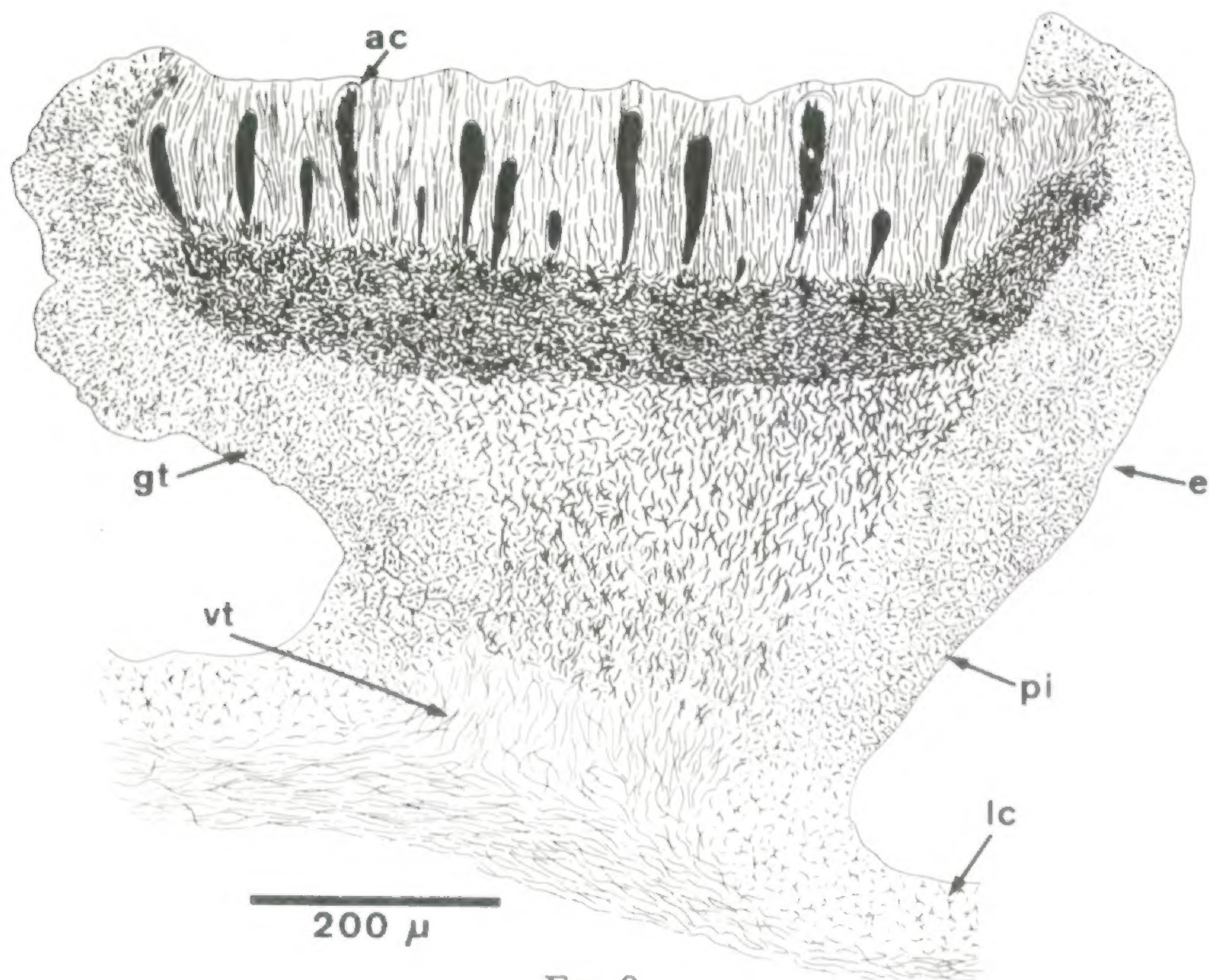


FIG. 9

is formed by generative tissue and a pseudopodetium by vegetative tissue", then it is impossible to arrive at a definite decision with regard to this lichen, for, as described above, both tissues take part in the formation of the "thallus verticalis." The same problem has been discussed (Jahns, 1970) in connection with the ontogeny of some genera of the Cladoniaceae with shortly stipitate fruiting bodies, and it has been decided to regard the nature of the tissue from which the *major* part of the fruiting body is formed, as diagnostic for the difference between a podetium and a pseudopodetium.

In *Calathaspis* the first stages are formed by generative tissue, after which the vegetative tissue participates briefly in the development, but in the final stage the generative tissue again dominates. The greater part of the mature apothecium and of its stalk consists of generative tissue, and for this reason *Calathaspis* can be regarded as having a true podetium. From the ontogenetic point of view, it seems most appropriate to place *Calathaspis* with the Cladoniaceae.

In the family of the Cladoniaceae as a whole a number of characteristic developmental stages are found which in different genera are repeated in different combinations. Ascogones and trichogynes formed in the cortex, before the generative tissue has appeared, are found not only in *Calathaspis* but also in *Heteromyces* Müll. Arg. A primordium of generative tissue which is elevated by the growth of the vegetative tissue is found in *Calathaspis* and in *Thysanothecium* Mont. & Berk. The sepa-

ration of vegetative and generative tissue by pigmentation of the latter, as seen in *Calathaspis*, has not been previously observed in the Cladoniaceae, but occurs in the genus *Pilophorus* Th. Fr., a member of the related family of the Stereocaulaceae.

Perhaps the most remarkable feature in the ontogeny of *Calathaspis* is the formation of the fruiting bodies from the underside of the thallus. As mentioned above, this feature has been observed also in the genus *Gymnoderma* Nyl., and for this reason it seems logical to assume that *Calathaspis* belongs to the family of the Cladoniaceae and is there most closely related to *Gymnoderma*.

Two collections from the type locality, McVean no. 6782 (type specimen) and Weber & McVean no. L-48411, were studied by thin-layer chromatography and found to have the same chemical constitution. The substance responsible for the rose- or orange-red reaction of the medulla with paraphenylenediamine gave on Kodak Chromagram Sheet K 301 V, using as solvent cyclohexane-chloroform-methylethylketone (9: 4.5: 0.6), and sprayed with paraphenylenediamine, a spot with a very low R_F value (0.06) similar to that obtained with the depsidone *pannarin*. Using other solvent systems, however, it could be ascertained that the R_F value is even lower than that of *pannarin*, indicating a different substance.

<i>TLC base</i>	<i>Solvent system</i>	<i>Pannarin</i>	<i>Calathaspis-substance</i>
Kodak Chromagram Sheet K 301 V	Cyclohexane : chloroform : methylethylketone (9: 5: 1)	R_F 0.12	R_F 0.06
Kodak Chromagram Sheet K 301 V	Toluol : AcOH (9: 1)	R_F 0.57	R_F 0.47
Silica gel plate PF 254-366	Benzol : dioxane : AcOH (90: 25: 4)	R_F 0.98	R_F 0.87

From the above results it can be ascertained that the chemical constituent of *Calathaspis devexa* is an unknown substance which may possibly be related chemically to *pannarin*. The relative paucity of the material available unfortunately precluded further investigation of this substance by other methods. It is interesting to note that the depside substance atranorin, which is commonly produced as a cortical constituent in most lichens, is absent in *C. devexa*.

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Explanation of Figures

Fig. 1. *Calathaspis devexa*: part of the type collection (McVean no. 6782). a, upper side; b, lower side. x 5. (Photograph by T. P. Maslin.)

Fig. 2. *Calathaspis devexa*: a group of fertile thallus squamules from the type collection (McVean no. 6782). a, upper side; b, lower side. x 8.

Fig. 3. *Calathaspis devexa*: structure of (a) thallus, (b) apothecium in section.

Fig. 4. *Calathaspis devexa*: spores.

Figs. 5-8. *Calathaspis devexa*: ontogenetic development of the fruiting body. 5, cross section of the thallus with an ascogone in the lower cortex. 6, young primordium of the fruiting body. 7, cross section of the thallus with a primordium of the fruiting body. 8, section of a young fruiting body. a, ascogonium; ah, ascogenous hyphae; al, algae; e, excipulum; gt, generative tissue; hy, hymenium; lc, lower cortex; m, medulla; t, trichogyne; uc, upper cortex; vt, vegetative tissue.

Fig. 9. *Calathaspis devexa*: ontogenetic development of the fruiting body (cont.). Section through a mature fruiting body. ac, ascus; e, excipulum; gt, generative tissue; lc, lower cortex; pi, pigment; vt, vegetative tissue.

